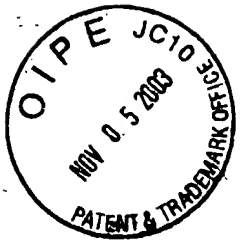


IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Group Art: 1722

Examiner: Thu Khanh T. Nguyen

Applicants: Oakey et al

APPEAL BRIEF

Serial No.: 09/928,827

Filed: August 13, 2001

For: **Method And Apparatus For Forming High-Impact, Transparent, Distortion-Free Polymeric Materials**

Mail Stop Appeal Brief – Patents
Director of the U.S. Patent and Trademark Office
P.O. Box 1450
Alexandria, Virginia 22313-1450

Dear Sir:

This is an appeal from the March 28, 2003 final rejection of Claims 26 through 35 of the above-identified application. Claims 1 through 25 and 36 through 38 have been withdrawn from this application. No claims have been cancelled. A copy of the Examiner's Final Office Action dated March 28, 2003 is attached as Exhibit A.

Claims 26 and 32 through 35 are rejected under 35 U.S.C. Section 102 (b) as being anticipated by Weisner et al (4,278,414). Claims 27 and 29 are rejected under 35 U.S.C. Section 103(a) as being unpatentable over the above Weisner reference, further in view of Weisner et al 4,352,776. Claim 28 is rejected under 35 U.S.C. Section 103(a) in view of the two Weisner references further in view of Bangerter et al. Also, Claims 30 and 31 are rejected under 35 U.S.C. Section 103(a) as being

unpatentable over the two Weisner et al references further in view of Christensen et al. No claims have been cancelled. The claims under appeal are Claims 26 through 35 and are reproduced and attached in Exhibit B. The references cited by the Examiner, specifically the two Weisner et al patents, Bangerter et al and Christensen et al are attached as Exhibit C.

REAL PARTY IN INTEREST

The named inventors are the real party of interest.

RELATED APPEALS AND INTERFERENCES

To the best of Applicants' knowledge, no other appeals or interferences are pending which will directly affect or be directly affected by or have a bearing on the Board's decision in the present pending appeal.

STATUS OF THE CLAIMS

Claims 26 through 35 stand finally rejected.

STATUS OF THE AMENDMENTS

No amendments were made to the claims after the Final Rejection on March 28, 2003.

SUMMARY OF THE INVENTION

The invention relates to a method of forming a sheet of polymeric material (16) as seen in Figure 1. The method includes heating the sheet (16) to a first

temperature wherein the sheet (16) is heated passed glass transformation temperature. The sheet (16) achieves a glass transition state. See Figure 5. The heating of the sheet (16) is terminated prior to placing the sheet in the first and second mold halves (12, 14). The sheet (16) is retained between the first and second mold halves (12, 14) of the forming mold with the sheet (16) supported along a peripheral edge of one of the first and second mold halves (12, 14). See Figure 4. A vacuum is generated on one side of the sheet (16) thereby drawing the sheet into an interior space of one of the first and second mold halves (12, 14). A center portion of the sheet (16) remains supported in a spaced relationship to the first and second mold halves (12, 14). See Figure 4. The sheet is cooled from the first temperature to a second temperature upon achieving a specific draw depth of the sheet within one of the first and second mold halves (12, 14). See Figure 4.

A copy of the patent application is attached as Exhibit D.

ISSUE

Applicants present the following issues for review:

1) Whether or not claims 26 and 32 through 35 are unpatentable under 35 U.S.C. §102(b) as being anticipated by Weisner et al (4,278,414).

2) Whether or not claims 27 and 29 are unpatentable under 35 U.S.C §103(a) over Weisner et al ('414) further in view of Weisner et al (4,352,776).

3) Whether or not claim 28 is unpatentable under 35 U.S.C. §103(a) over the above Weisner patents further in view of Bangerter et al.

4) Whether or not claims 30 and 31 are unpatentable under 35 U.S.C. §103(a) over the above two Weisner patents further in view of Christensen et al.

GOUPING OF THE CLAIMS

Claims 26 and 32 stand or fall together. Claims 27 and 28 stand or fall together. Claims 29 through 31 stand or fall together. Claim 33 stands by itself. Claim 34 stands by itself. Claim 35 stands by itself.

ARGUMENT

BACKGROUND OF THE INVENTION

The present invention relates to a method of forming polymeric materials to form distortion free polymeric materials. Traditionally, acrylic plastic is used to form transparent panels. Acrylic plastic is noted for its excellent optical properties and weatherability, having outstanding resistance to the effect of sunlight and exposure to the elements over a long period of time. Subjected to long exposure to the elements, acrylic plastic does not experience significant yellowing or any other significant change in physical properties. Acrylic plastic, however, does not have as high an impact strength as do other polymeric materials and thus, are less preferred for application where impact strength is of importance.

Polymeric sheets of acrylic plastic are formed using molds that include contoured upper and lower surfaces. The contoured surfaces define the desired shape of the polymeric sheet, directly contacting the entire upper and lower surfaces of the polymeric sheet. Because of the hardness of the upper and lower surfaces of an acrylic plastic sheet, it may be formed in this manner without distorting the upper and lower surfaces. However, the upper and lower surfaces of

a polycarbonate sheet are not as hard and therefore, when heated, may be distorted upon contact during the forming process. For this reason, the use of traditional molds which directly contact the upper and lower surfaces of the polymeric sheet are not desirable for forming polycarbonate sheets. Traditional molds have increased potential for distorting the surfaces of the polycarbonate sheet, thus producing an increased number of rejected panels and driving up production costs.

The present invention provides a method for forming polymeric material. The method provides for heating a sheet of material passed the glass transformation temperature. The heating is terminated prior to the sheet being placed in first and second molds. Once in the molds, a vacuum draws the sheet into the interior of the mold halves. The sheet is cooled from the first temperature to the second temperature upon achieving a specific draw depth of the sheet within the first and second mold halves. The Weisner '414 patent neither, by itself nor in combination with the Weisner '776 or Bangerter et al or Christensen et al anticipate or render the present invention obvious to those skilled in the art. The Examiner's combinations fail to disclose or suggest Applicants' invention.

The Examiner alleges that the Weisner '414 patent anticipates Applicants' invention. For a reference to be a proper reference under 35 U.S.C. §102, the reference must meet a two step inquiry. The court of appeals for the federal circuit has recently stated that a "rejection for anticipation or lack of novelty requires, as the first step in the inquiry, that the elements of the claimed invention be described in a single reference." (Cite omitted). Further, the reference must describe the Applicants' claimed invention sufficiently to have placed a person of ordinary skill

in the field of the invention in possession of it. (Cite omitted). In re Spada, 15 U.S.P.Q. 2d (Fed. Cir. 1990)1655 at 1657.

The Weisner '414 patent fails on both accounts. First, Weisner '414 fails to disclose the heating of the sheet passed a glass transition temperature. Next, Weisner fails to disclose terminating the heating of the sheet prior to placing it in the first and second molds. In fact, Weisner teaches:

"The loaded clamp is rotated to the heating station 46 where it is heated and molded at 47 of Figure 4. The clamping frames and thin polymer sheets are heated to soften the thin polymer sheets at which time an upper platen is closed at predetermined distance adjacent a lower platen 50 in step 51". Column 3, lines 49 through 54.

Thus, Weisner '414 teaches constantly heating the polymeric sheet during forming of the polymeric sheet. Nowhere does it describe the termination of heating prior to putting the sheet into the molded halves. Further, nowhere does the Weisner '414 patent disclose cooling of the sheet from the first temperature to second temperature upon achieving a specific drawn depth of the sheet while it is within the first and second mold halves. Weisner removes the sheet from the mold in order for the sheet to begin cooling. Since Weisner continues heating all during the drawing process, even as the drawing occurs, the plastic sheet is not cooled as suggested by the Examiner. Thus, since the Weisner '414 patent does not disclose all of the elements of Applicants' claimed invention, it is an improper reference under §102. Accordingly, Weisner '414 fails as a §102 reference.

Next, the Examiner alleges that the Weisner '414 patent would be combined with the Weisner '776 patent. The Weisner '776 patent points out that during molding, the apparatus unavoidably shields the flange area from being heated from

below and partially shields that area from the upper heating elements. Therefore, less heat is introduced into the flanges by the heater than is introduced into the central portion of the sheet. The metal surface of the clamps acts as heat sink and tends to draw heat out of the plastic. Weiser '776 overcomes this problem by providing heated clamp frames and by carefully balancing the heat from the clamping frames and the heat from the heaters during the heating stage. The '776 patent indicates that the heating clamp frames remain energized during forming to prevent the flange area of the sheet from prematurely cooling. Further, the '776 patent illustrates heating continuously during the forming process. Thus, the combination of Weisner '776 patent with the Weisner '414 patent fails to render Applicants' invention obvious to those skilled in the art since the heating of the sheet is not terminated prior to placing the sheet into the mold. Further, Weisner '776 indicates that the male and female sections of the step molds are heated to prevent undesirable cooling. Thus, the Weisner '776 as does the Weisner '414 patent fails to disclose cooling of the sheet material while the sheet is in the mold halves. Thus, these references fail to disclose or suggest Applicants' invention.

The Bangerter et al reference relates to a part sensing device. The Bangerter reference discloses a device for sensing the presence or absence of newly formed parts. This reference fails to overcome the deficiency of the two Weisner references. Further, the addition of the Bangerter reference with the two Weisner et al references utilizes hindsight reconstruction. The Examiner cannot use Applicants' invention as a template to piece together her rejection. This picking and choosing is improper under §103.

The Christensen reference relied on by the Examiner, fails to overcome the deficiency of the two Weisner references. Christensen relates to trimming film. Once again, the Examiner is using Applicants' invention as a template to piece together her rejection. Accordingly, this picking and choosing utilizing Applicants' invention as a template flies in the face of §103.

Claims 26 and 32 stand or fall together. Claims 27 and 28 stand or fall together. Claims 29 through 31 stand or fall together. There is no teaching in the art of the trimming as claimed by Applicants.

Claim 33 stands by itself. The Weisner '414 patent, cited by the Examiner, does not teach the temperature greater than or equal to a glass transition temperature and less than the melting temperature of the sheet.

Claim 34 stands by itself. The Weisner reference does not show a second temperature less than the glass transition temperature of the sheet. Thus, the Weisner '414 patent fails to disclose Claim 34.

Claim 35 stands by itself. The Weisner '414 patent does not disclose heating of the sheet in stages. Further it does not show the heating of the sheet in stages prior to entering the sheet into the molds. Thus, Weisner '414 fails to disclose Claim 35.

CONCLUSION

Applicants respectfully submit that the Examiner has not proved that the Weisner '414 patent anticipates Applicants' invention. Further, the Examiner's combinations fail to present a prima facie case of obviousness as the references

cited do not teach the method of the claimed invention. In fact, both the Weisner references teach heating of the sheet material while it is in the mold halves. Further, both references fail to disclose cooling of the sheet material while it is in the mold. Thus, the Examiner's anticipation rejection does not disclose all the elements of Applicants' invention. Further, the Examiner's claimed combination would not render the invention obvious to those skilled in the art.

Applicants' invention provides the art with an improved method of forming a polymeric sheet material that is neither anticipated or suggested or disclosed by the prior art. Accordingly, reversal of the final rejection of Claims 26 through 35 and allowance of the claims is respectfully requested.

Respectfully submitted,

Harness, Dickey & Pierce, P.L.C.

Dated: November 3, 2003

BY: _____
W. R Duke Taylor
Reg. No. 31,306
Attorneys for Applicants

P.O. Box 828
Bloomfield Hills, MI 48303

(248) 641-1600

Attorney Docket No. 1543-000002

WRDT/jp
Enclosures

EXHIBIT A

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER OF PATENTS AND TRADEMARKS
Washington, D.C. 20231
www.uspto.gov

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
09/928,827	08/13/2001	Edwin J. Oakey	1543-000002	8746

27572 7590 03/28/2003

HARNESS, DICKEY & PIERCE, P.L.C.
P.O. BOX 828
BLOOMFIELD HILLS, MI 48303

EXAMINER
NGUYEN, THUKHANH T

ART UNIT	PAPER NUMBER
1722	10

DATE MAILED: 03/28/2003

Please find below and/or attached an Office communication concerning this application or proceeding.

1595-000002
Final 01A
Due 6-28-03

✓ WKD 1

Office Action Summary

Application No.	Applicant(s)
09/928,827	OAKEY ET AL.
Examiner	**Art Unit**
Thu Khanh T. Nguyen	1722

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for R ply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If the period for reply specified above is less than thirty (30) days, a reply within the statutory minimum of thirty (30) days will be considered timely.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133).
- Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☐ Responsive to communication(s) filed on _____ .

2a)☒ This action is **FINAL**. 2b)☐ This action is non-final.

3)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

4)☒ Claim(s) *1-38* is/are pending in the application.

4a) Of the above claim(s) *1-25 and 36-38* is/are withdrawn from consideration.

5)☐ Claim(s) _____ is/are allowed.

6)☒ Claim(s) *26-35* is/are rejected.

7)☐ Claim(s) _____ is/are objected to.

8)☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

9)☐ The specification is objected to by the Examiner.

10)☐ The drawing(s) filed on _____ is/are: a)☐ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

11)☐ The proposed drawing correction filed on _____ is: a)☐ approved b)☐ disapproved by the Examiner.

If approved, corrected drawings are required in reply to this Office action.

12)☐ The oath or declaration is objected to by the Examiner.

Pri rity under 35 U.S.C. §§ 119 and 120

13)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

a)☐ All b)☐ Some * c)☐ None of:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____ .

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

14)☐ Acknowledgment is made of a claim for domestic priority under 35 U.S.C. § 119(e) (to a provisional application).

a) ☐ The translation of the foreign language provisional application has been received.

15)☐ Acknowledgment is made of a claim for domestic priority under 35 U.S.C. §§ 120 and/or 121.

Attachment(s)

1) ☒ Notice of References Cited (PTO-892)
2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
3) ☐ Information Disclosure Statement(s) (PTO-1449) Paper No(s) _____ .
4) ☐ Interview Summary (PTO-413) Paper No(s). _____ .
5) ☐ Notice of Informal Patent Application (PTO-152)
6) ☐ Other: .

DETAILED ACTION

Claim Rejections - 35 USC § 102

1. The following is a quotation of the appropriate paragraphs of 35 U.S.C. 102 that form the basis for the rejections under this section made in this Office action:

> A person shall be entitled to a patent unless –
>
> (b) the invention was patented or described in a printed publication in this or a foreign country or in public use or on sale in this country, more than one year prior to the date of application for patent in the United States.

2. Claims 26 and 32-35 are rejected under 35 U.S.C. 102(b) as being anticipated by Weisner et al (4,278,414).

Weisner et al ('414) teach an apparatus and method for forming plastic skylights. The method comprises the steps of (claim 26):

1- heating the sheet to a first temperature or a forming state (46; col. 1, last line to col. 2, 1st line),

2 - terminating heating of the sheet by removing the sheet from the heating station (col. 2, lines 1-2),

3 - retaining the sheet between the first and second mold halves with the sheet being supported along a peripheral edge of the mold halves (Fig. 6; col. 3, lines 51-60),

4 - generating a vacuum on one side of the sheet to draw the sheet into an interior space of one of the mold halves while the center portion of the sheet remains supported in space relationship to the mold halves (Fig. 6, col. 3, line 62 to col. 4, line 2 – claim 32); and

5 – cooling the sheet to a second temperature by removing the sheet from the heating station, by vacuum forming in which the mold might not be heated (col. 4, lines 43-44), and by unloading the sheet from the forming station (col. 4, lines 2-4 – claim 26 & 32).

Wherein the first temperature is greater than or equal to the glass transition temperature in order for the sheet material to be softened and to be reformed (col. 3, lines 51-64 – claim 33); and wherein the second temperature is less than a glass transition temperature of the sheet in order for the formed article retaining the shape after molding (col. 4, lines 2-5 – claim 34).

Further heating of the sheet occurs in stages (col. 4, lines 35-43 – claim 35).

Claim Rejections - 35 USC § 103

3. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

4. Claims 27 and 29 are rejected under 35 U.S.C. 103(a) as being unpatentable over Weisner et al ('414) as applied to claims 26 and 32-35 above, and further in view of Weisner et al (4,352,776).

Weisner et al ('414) disclose a method for forming skylights as described above, but fail to disclose the step of detecting a draw depth of the sheet within the mold half and the step of trimming a perimeter of the sheet to a desired shape.

Weisner et al ('776) disclose an apparatus and method for fabricating polycarbonate skylights, comprising the steps of:

i - trimming the sheet to a predetermined size and shape (col. 7, lines 58-59);

ii - detecting the draw depth of the sheet in between the mold (col. 8, lines 47-51) for turning off the vacuum and start the cooling step, and

iii - turning off the vacuum (col. 8, lines 50-52) by any means such as a photo cell, a micro-switch.

It would have been obvious to one of ordinary skill in the art at the time the applicant's invention was made to modify Weisner et al ('414) by providing the steps of trimming and detecting the draw depth of the sheet as taught by Weiner et al ('776) because the step of trimming the sheet would resulted in products having a predetermined size and shape ('776; col. 7, line 59), while the step of detecting the draw depth of the sheet would facilitate the controlling of the height product being formed ('776; col. 8, line 49).

5. Claims 27 and 29 are rejected under 35 U.S.C. 103(a) as being unpatentable over Weisner et al ('414) in view of Weisner et al ('776) as applied to claims 26, 27, 29 and 32-35 above, and further in view of Bangerter et al (4,603,329).

Weisner et al disclose a method for forming skylights as described above, in which the vacuum is turned off by controlling the height of the dorm, but fails to disclose that the step of detecting the draw depth using a laser and sensor.

Bangerter et al disclose a device and method for sensing the present of the formed article comprising a sensor and a laser (col. 3, lines 28-30).

It would have been obvious to one of ordinary skill in the art at the time the applicant's invention was made to modify Weisner et al by providing a laser and sensor as taught by Bangerter et al, because the laser and the sensor would be more accurate in determining the position of the forming article compared to other sensors.

6. Claims 30-31 are rejected under 35 U.S.C. 103(a) as being unpatentable over Weisner et al ('414) in view of Weisner et al ('776) as applied to claims 26, 27, 29 and 32-35 above, and further in view of Christensen et al (6,367,361).

Weisner et al disclose a method of forming a plastic sheet into skylights, including the step of trimming the sheet to an appropriate size and shape before forming, but fail to disclose that the trimming was done by using a blade or a series of blades disposed about a perimeter of the mold half.

Christensen et al disclose a method and an apparatus for trimming thermoformed films, comprising the step of trimming the formed films by using a plurality of movable blades (38) for trimming a three-dimensional film-preform (col. 4, lines 15-25).

It would have been obvious to one of ordinary skill in the art at the time the applicant's invention was made to modify Weisner et al by providing a blade or a plurality of blades around the peripheral of the forming mold as taught by Christensen et al, because the blades would facilitate the trimming of the sheet at different locations and dimensions.

Response to Arguments

7. Applicant's arguments with respect to claims 26-35 have been considered but are moot in view of the new ground(s) of rejection.

As agreed with the Attorney during the interview, Weisner et al ('776) fail to disclose the step of heating the sheet prior to placing the sheet into the mold halves. However, when updated the search, Weisner et al ('414) has been found. This reference discloses the step of completing the heating of the sheet material prior to place the sheet into the mold cavity, in

which the sheet is freely drawn by the vacuum to form a dome-shaped article. Weisner et al ('776) disclose the steps of trimming and detecting a draw depth of the sheet. Bangerter et al disclose the step of using sensor and laser to detect the position of the sheet. Christensen et al disclose the step of trimming the formed products by the blades. It would have been obvious to a skilled artisan to improved Weisner et al ('414) by providing additional steps such as trimming the film to form articles with a predetermined size and shape by a plurality of blade, so that the trimming can be controlled at different position, detecting the sheet position by a laser sensing means as taught by Weisner ('776), Bangerter and Christensen to improve the process of free drawing sheet material.

Conclusion

8. Applicant's amendment necessitated the new ground(s) of rejection presented in this Office action. Accordingly, **THIS ACTION IS MADE FINAL**. See MPEP § 706.07(a). Applicant is reminded of the extension of time policy as set forth in 37 CFR 1.136(a).

A shortened statutory period for reply to this final action is set to expire THREE MONTHS from the mailing date of this action. In the event a first reply is filed within TWO MONTHS of the mailing date of this final action and the advisory action is not mailed until after the end of the THREE-MONTH shortened statutory period, then the shortened statutory period will expire on the date the advisory action is mailed, and any extension fee pursuant to 37 CFR 1.136(a) will be calculated from the mailing date of the advisory action. In no event, however, will the statutory period for reply expire later than SIX MONTHS from the date of this final action.

9. Any inquiry concerning this communication or earlier communications from the examiner should be directed to Thu Khanh T. Nguyen whose telephone number is 703-305-7167. The examiner can normally be reached on Monday- Friday, 6:30-4:00.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Wanda L Walker can be reached on 703-308-0457. The fax phone numbers for the organization where this application or proceeding is assigned are 703-872-9310 for regular communications and 703-872-9311 for After Final communications.

Any inquiry of a general nature or relating to the status of this application or proceeding should be directed to the receptionist whose telephone number is 703-308-0661.

TN
March 18, 2003

Walker
W. L. WALKER
SUPERVISORY PATENT EXAMINER
TECHNOLOGY CENTER 1700

Notice of References Cited	Application/Control No. 09/928,827	Applicant(s)/Patent Under Reexamination OAKEY ET AL.	
	Examiner Thu Khanh T. Nguyen	Art Unit 1722	Page 1 of 1

U.S. PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Name	Classification
	A	US-4,278,414	07-1981	Weisner et al.	425/388
	B	US-5,843,492	12-1998	McCorry, Richard P.	425/397
	C	US-			
	D	US-			
	E	US-			
	F	US-			
	G	US-			
	H	US-			
	I	US-			
	J	US-			
	K	US-			
	L	US-			
	M	US-			

FOREIGN PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Country	Name	Classification
	N					
	O					
	P					
	Q					
	R					
	S					
	T					

NON-PATENT DOCUMENTS

*		Include as applicable: Author, Title Date, Publisher, Edition or Volume, Pertinent Pages)
	U	
	V	
	W	
	X	

*A copy of this reference is not being furnished with this Office action. (See MPEP § 707.05(a).)
Dates in MM-YYYY format are publication dates. Classifications may be US or foreign.

EXHIBIT B

CLAIMS UNDER APPEAL

EXHIBIT "B"

26. A method for forming a sheet of polymeric material, comprising the steps of:

heating the sheet to a first temperature wherein the sheet is heated past a glass transition temperature and said sheet achieves a glass transition state;

terminating heating of said sheet prior to placing in first and second mold halves;

retaining the sheet between first and second mold halves of a forming mold with the sheet supported along a peripheral edge of one of said first and second mold halves;

generating a vacuum on one side of the sheet thereby drawing the sheet into an interior space of one of said first and second mold halves while a center portion of the sheet remains supported in space relationship to said first and second mold halves; and

cooling the sheet from said first temperature to a second temperature upon achieving a specified draw depth of the sheet within one of said first and second mold halves.

27. A method for forming a sheet of polymeric material as set forth in claim 26, further comprising the step of detecting a draw depth of the sheet within one of said first and second mold halves for initiating said cooling.

28. A method for forming a sheet of polymeric material as set forth in claim 27, wherein said detecting of said draw depth is achieved using a laser and sensor.

29. A method for forming a sheet of polymeric material as set forth in claim 26, further comprising the step of trimming a perimeter of the sheet to a desired shape.

30. A method for forming a sheet of polymeric material as set forth in claim 29, wherein said trimming of said perimeter is achieved using a blade disposed about a perimeter of one of said first and second mold halves for trimming said perimeter of the sheet upon retention of the sheet between said first and second halves.

31. A method for forming a sheet of polymeric material as set forth in claim 29, wherein said trimming of said perimeter is achieved using a series of blades disposed about a perimeter of one of said first and second halves, wherein each of said blades includes an angled cutting edge thereby providing a series of progressive trimming sections along said perimeter.

32. A method for forming a sheet of polymeric material as set forth in claim 26, further comprising the steps of:

relieving said vacuum from said one side of the sheet;

withdrawing one of said first and second mold halves from the other of said first and second mold halves; and

removing said sheet from said forming mold.

33. A method for forming a sheet of polymeric material as set forth in claim 26, wherein said first temperature is greater than or equal to a glass transition temperature of the sheet and less than a melting temperature of the sheet.

34. A method for forming a sheet of polymeric material as set forth in claim 26, wherein said second temperature is less than a glass transition temperature of the sheet.

35. A method for forming a sheet of polymeric material as set forth in claim 26, wherein said heating of the sheet occurs in stages.

EXHIBIT C
U S PATENT
09928827

EXHIBIT D

METHOD AND APPARATUS FOR FORMING HIGH-IMPACT, TRANSPARENT, DISTORTION-FREE POLYMERIC MATERIALS

BACKGROUND AND SUMMARY OF THE INVENTION

[0001] The present invention relates generally to forming polymeric materials and more particularly to a method and apparatus for forming distortion-free polymeric materials.

[0002] Polymeric materials are used in a wide variety of applications. Typically, polymeric materials are used to manufacture transparent panels such as windows or windshields for various applications including aircraft, automobiles, motorcycles, boats and the like. Such applications, especially those for aircraft, require an extremely clear, undistorted, transparent panel, which is resistive to scratching and impact in order to afford the pilot a clear view of the surroundings.

[0003] Traditionally, acrylic plastic is used to form such transparent panels. Acrylic plastic is noted for its excellent optical properties and weatherability, having outstanding resistance to the effects of sunlight and exposure to the elements over long periods of time. Subjected to long term exposure to the elements, acrylic plastic does not experience significant yellowing or any other significant changes in its physical properties. Acrylic plastic, however, does not have as high an impact strength as do other polymeric materials and thus, are less preferred for applications where impact strength is of importance.

[0004] Polycarbonate is a high-performance thermoplastic with the characteristics of high impact strength, optical clarity, heat resistance and dimensional stability. Polycarbonate, on the other hand, does not include the same weatherability characteristics of acrylic plastic. However, the transparent panels, whether produced using acrylic plastic or polycarbonate, include a hard protective coating to prevent scratching, abrasions or other markings that would reduce the service life of the transparent panel. Further, the hard protective coating protects the base sheet, whether acrylic plastic or polycarbonate, from UV degradation. As a result, the transparent panel is protected from any degradation, such as yellowing, abrasion distorting, and the like, even though the base sheet (e.g. polycarbonate) would otherwise degrade from such exposure. Therefore, it is desirable in the industry to use polycarbonate for producing transparent panels because of its high impact strength, while it remains protected from UV degradation and abrasion by the protective coating which is applied regardless of the material used.

[0005] Traditionally, polymeric sheets of acrylic plastic are formed using molds that include contoured upper and lower surfaces. The contoured surfaces define the desired shape of the polymeric sheet, directly contacting the entire upper and lower surfaces of the polymeric sheet. Because of the hardness of the upper and lower surfaces of an acrylic plastic sheet, it may be formed in this manner without distorting the upper and lower surfaces. However, the upper and lower surfaces of a polycarbonate sheet are not as hard and therefore, when heated, may be distorted upon contact during the forming process. For this

reason, the use of traditional molds, which directly contact the upper and lower surfaces of the polymeric sheet, are not desirable for forming polycarbonate sheets. Traditional molds have increased potential for distorting the surfaces of the polycarbonate sheet, thus producing an increased number of rejected panels and driving up production costs.

[0006] Accordingly, the present invention provides an apparatus for forming a polymeric material, such as polycarbonate. The present invention enables forming of a polycarbonate sheet without distorting the key visibility areas of the sheet. The apparatus of the present invention provides a forming mold including a first half having a bottom wall and a first side wall defining a first interior space and a first edge and a second half having a top wall and a second side wall defining a second interior space and a second edge. The first and second halves come together to clamp the peripheral edge portions of a sheet of polymeric material therebetween for forming the sheet whereby the sheet is vacuum drawn into one of the first and second interior spaces. A cooling mechanism is disposed within one of the first and second interior spaces and a sensing mechanism is attached to one of the first and second halves for sensing a draw depth of the sheet within one of the first and second interior spaces. The first edge is preferably contoured for defining a final edge contour of the sheet and the second edge correspondingly contoured for facilitating engagement of the first and second halves. Further, the first edge is preferably beveled and the second edge correspondingly beveled for facilitating engagement of the first and second halves.

[0007] In a preferred embodiment, a trimming mechanism is provided for trimming a perimeter of the sheet to a desired shape. A retention mechanisms is also provided and operatively supported by one of the first and second halves for biasing the sheet into contact with one of the first and second edges of the first and second halves.

[0008] The present invention further provides an improved method for forming a sheet of polymeric material. The method of the present invention includes the steps of: heating the sheet to a first temperature, retaining a sheet between first and second mold halves of a forming mold, generating a vacuum on one side of the sheet thereby drawing the sheet into an interior space of one of the first and second mold halves, and cooling the sheet from the first temperature to a second temperature upon achieving a specified draw depth of the sheet within one of the first and second mold halves. The method preferably includes the step of detecting a draw depth of the sheet within one of the first and second mold halves for initiating the cooling. Alternatively, the heated sheet may be formed by use of blow air to exert a pressure on the other side of the sheet in lieu of the vacuum forming process or perhaps by use of a combination of both blow air and vacuum on opposite sides of the sheet.

[0009] Further areas of applicability of the present invention will become apparent from the detailed description provided hereinafter. It should be understood that the detailed description and specific examples, while indicating the preferred embodiment of the invention, are intended for purposes of illustration only and are not intended to limit the scope of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] The present invention will become more fully understood from the detailed description and the accompanying drawings, wherein:

[0011] Figure 1 is a perspective view of a forming mold in accordance with the present invention;

[0012] Figure 2 is a top view of the forming mold of Figure 1;

[0013] Figure 3 is a side view of a lower half of the forming mold;

[0014] Figure 4 is a sectional view of the forming mold taken along line 4-4 of Figure 2;

[0015] Figure 5A is a detailed view of a retention mechanism of the forming mold;

[0016] Figure 5B is a view of an alternative embodiment of a trimming means;

[0017] Figure 6 is a perspective view of the lower half of the forming mold having a finished polymeric sheet resting thereon.

[0018] Figure 7 is a perspective view of the forming mold including an alternative trimming means; and

[0019] Figure 8 is a schematic view of an exemplary processing line for forming the polymeric material.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0020] The following description of the preferred embodiments is merely exemplary in nature and is in no way intended to limit the invention, its application, or uses.

[0021] With reference to the Figures, there is shown a forming mold 10 including upper and lower halves 12,14 that come together to form a heated sheet of polymeric material 16 therebetween. The sheet 16 is preferably an optical quality polycarbonate material and is retained within a rigid frame 17 having a length and width somewhat greater than that of the upper and lower halves 12,14, and that clamps about the complete peripheral edge of the sheet 16. Edges of the upper and lower halves 12,14 are contoured to define a desired end form for peripheral edges of the sheet 16. A vacuum is created within an interior space 18 of the lower half 14 for drawing the sheet 16 downward, thereby forming the sheet 16 as defined by the contoured edges of the upper and lower halves 12,14. The drawing process ensues until the sheet 16 crosses a trigger point whereby the vacuum draw ceases and cooling mechanisms 20, disposed within an interior space 22 of the upper half 12, act to cool the sheet 16 in its desired end form. Alternatively, rather than drawing a vacuum in interior space 18, the gas pressure in interior space 18 may be increased by supplying pressurized gas thereto to exert a forming force on sheet 16 or both a vacuum within space 18 and increased gas pressure within space 22 may be utilized to accomplish the forming operation.

[0022] In an exemplary embodiment, the forming mold 10 is configured for forming an aircraft windshield. As best seen in Figure 2, the perimeter of the forming mold 10 is correspondingly shaped for the particular application. It will be appreciated, however, that the forming mold 10 can be configured to form sheets 16 into various shapes and contours in accordance with the requirements of a variety of applications. The lower half 14 includes a bottom wall 24 and four sidewalls 26,28,30,32 defining the interior space 18. The sidewalls 26,28,30,32 have upper edges 34,36,38,40, respectively, and are selectively contoured along their lengths for defining the end form of the peripheral edge of sheet 16. The upper edges 34,36,38,40 are preferably beveled, sloping downward toward the interior of the lower half 14. The upper half 12 includes a top wall 42 and four sidewalls 44,46,48,50 defining the interior space 22. The sidewalls 44,46,48,50 have lower edges 52,54,56,58, respectively, and are correspondingly contoured along their lengths to engage the upper edges 34,36,38,40. The lower edges 52,54,56,58 are preferably beveled sloping downward toward the interior of the lower half 14 for corresponding alignment with the beveled upper edges 34,36,38,40. The lower half 14 further includes an opening 60 for drawing air from the interior space 22. In this manner, a vacuum may be created within the interior space 18 for forming the sheet 16, as will be described in further detail below.

[0023] As seen in figure 4 a series of retention mechanisms 62 are preferably included around the perimeter of the upper half 12 and are operatively disposed within the sidewalls 44,46,48,50 of the upper half 12. As best shown in

Figure 5A, the sidewalls 44,46,48,50 include a series of cavities 64 therein having openings 66 through the beveled lower edges 52,54,56,58. The retention mechanisms 62 each include a retention pin 68 that is partially disposed within the cavity 64. The retention pin 68 includes a pin portion 70 slidably disposed in and extending outwardly through the opening 66 and an enlarged diameter head 72 slidably disposed within the cavity 64. The pin portion 70 includes a rounded end face 71. The retention mechanism 62 further includes a spring 74 disposed between an upper face 76 of the cavity 64 and a top face 78 of the retention pin 68. The spring 74 biases the retention pin 68 downward through the opening 66. Also included is an access cover 77 for providing access to the cavity 64. The access cover 77 runs the length of the cavity 64 and is held in position by a series of screws 79. In this manner, the retention mechanisms 62 can be assembled into and accessed within the sidewalls 44, 46, 48, 50.

[0024] The retention mechanism 62 retains the sheet 16 in position between the upper and lower halves 12,14 throughout the hereindescribed forming process, whereby the rounded end face 71 of the pin portion 70 is biased into contact with the sheet 16. It will be appreciated, however, that the retention mechanisms 62 may be alternatively housed within the sidewalls 26,28,30,32 of the lower half 14, whereby the spring 74 biases the retention pin 68 upward through the opening 66.

[0025] A sensing mechanism 80 is provided and is mounted to the sidewall 28 of the lower half 14. In accordance with a first preferred embodiment, the sensing mechanism 80 includes a laser 82. The laser 82 selectively

generates a beam of laser light 84 that travels across the interior space 18 of the lower half 14 and is reflected by a reflector 86, fixedly attached to the side wall 32. The laser 82 includes a sensor for sensing the reflected beam 84. In accordance with a second preferred embodiment, the sensing mechanism 80 includes an optical sensor such as a video camera or the like. The beam emitted by the sensing mechanism 80 or the line of sight is positioned so as to be intersected and/or interrupted by the lowest most point of sheet 16 as it is formed to its finished shape. When this point is detected by sensor 80, sensor 80 generates a control signal to discontinue the vacuum as well as to trigger a cooling stage, as will be described in further detail hereinbelow.

[0026] The cooling mechanisms 20 are disposed within the interior space 22 of the upper half 14, fixedly attached to the top wall 42. In a first preferred embodiment, the cooling mechanisms 20 include fans for circulating air through the interior space 22 of the upper half 14. Alternatively, it is anticipated that the cooling mechanisms 20 may also include other air blowing or circulating means known in the art, such as blowing ducts and the like which may draw air from outside mold 10 or may include apparatus for cooling the air being circulated thereby. The cooling mechanisms 20 circulate cooling air for cooling the sheet 16 after forming, as described in further detail hereinbelow.

[0027] The forming mold 10 further includes trimming means 88 for trimming edges of the sheet 16 as defined by the external shape of the forming mold 10. In a first preferred embodiment, the trimming means 88 includes a series of blades 90 fixedly attached about the perimeter of the upper half 12 by

bolts 91. The blades 90 extend downward past the lower edges 52,54,56,58 of the sidewalls 44,46,48,50 and include a sharpened leading edge 92. As the upper and lower halves 12,14 come together to retain the sheet 16 therebetween, the blades 90 simultaneously cut through the sheet 16, cutting away excess material and forming a perimeter of the sheet 16 as defined by the perimeter of the forming mold 10. As shown the pin portion 70 preferably extends past the leading edge 92 so as to contact the sheet 16 prior to the engagement of the sharpened leading edge 92 therewith so as to insure it is securely retained in position during the trimming operation. Additionally, it should be noted that in a preferred embodiment, as shown in FIG. 5B, there are a plurality of blades 90 along each edge with each leading edge 92 being angled relative to the surface of the sheet 16 so as to provide a series of progressive trimming sections along each side of sheet 16 and thus reduce the force required to accomplish same.

[0028] It is also anticipated that alternative trimming means 88 may be implemented for trimming the perimeter of the sheet 16. Such means include a laser, a high-speed water jet, and the like. In such an arrangement, a laser trimming or water jet trimming mechanism may be provided to orbit the perimeter of the forming mold 10, trimming away excess material as it travels. After the mold has been moved to a closed position. An exemplary embodiment of the alternative trimming means in detailed in Figure 7.

[0029] A controller 100 is provided and is in electrical communication with various components of the forming mold 10, including the sensing

mechanism 80 and the cooling mechanism 20. Depending upon the particular embodiment, the controller 100 may also be in electrical communication with laser or water jet trimming mechanisms for controlling their activity. The controller 100 controls the forming process as discussed in detail below.

[0030] The present invention provides a method of forming the sheet 16 of polymeric material, preferably utilizing the above-detailed forming mold 10. With particular reference to Figure 8, the method of the present invention will be described in detail. Initially, at step 200, the sheet 16 is loaded into the frame 17. The sheet 16 is heated in one or more stages, represented as steps 210, 220, 230, until it is heated past a glass transition temperature, achieving a glass-transition stage, thereby becoming viscous or rubbery. It should be noted, however, that the sheet should not be heated to the point that it reaches a melting temperature, whereby the sheet would melt and become scrap. The number of heating stages, their respective lengths and temperatures, may vary in accordance with the type of material and thickness of material used. Heating the sheet 16 in stages is believed preferable to avoid possible blistering or other deformation of the surface of the sheet 16 that could otherwise occur.

[0031] The sheet 16 is subsequently brought into the forming stage, at step 240, and placed on top of the lower half 14, with a bottom surface 102 resting on the upper edges 34,36,38,40 of the sidewalls 26,28,30,32. The upper half 12 travels downward in alignment with the lower half 14, whereby the lower edges 52,54,56,58 of the side walls 44,46,48,50 engage an upper surface 104 of the sheet 16 thereby forming the area around the periphery of the sheet 16 to the

contour of edges 52,54,56,58 and retaining the sheet 16 between the upper and lower edges. The frame holds the perimeter of the sheet 16 in rigid form, and thus the sheet 16 is pulled and stretched as it is enclosed within the forming mold 10. Concurrently, the retention mechanisms 62 provide a downward force, biasing the bottom surface 102 of the sheet 16 into tight engagement with the upper edges 34,36,38,40 of the sidewalls 26,28,30,32, creating an airtight seal therebetween. Additionally, the edges of the sheet 16 are trimmed in accordance with the perimeter shape of the forming mold 10. In accordance with the preferred embodiment, trimming of the sheet 16 occurs concurrently with the closing of the upper and lower halves 12,14, whereby the blades 90 cut through the sheet 16 as the upper half 14 engages the upper surface 104 of the sheet 16. In an alternative embodiment, however, trimming may occur subsequent to the upper and lower halves 12,14 closing, whereby a laser or water-jet trimming mechanism travels about the perimeter of the forming mold 10 or the knives may be movable relative to upper half 12 and employ a separate activating mechanism to perform the trimming operation. Alternatively, the trimming operation may be performed once sheet 16 has been formed by any one of a laser, water-jet or separately actuated knives.

[0032] Once the sheet 16 is retained between the upper and lower halves 12,14, a vacuum is created within the interior space 18 of the lower half 12 by drawing air from the interior space 18, through the opening 60. The vacuum is achievable due to the airtight seal between the bottom surface 102 of the sheet 16 and the upper edges 34,36,38,40 of the sidewalls 26,28,30,32. As

a result, the sheet 16 is drawn downward by the vacuum force into the interior space 18, thus forming the desired shape. The sensing mechanism 80 senses when the sheet achieves a particular draw depth within the interior space 18. Upon sensing the sheet 16 achieving the draw depth, the cooling mechanisms 20 are activated for cooling the sheet 16 below its glass-transition temperature, thereby again achieving a rigid state. The vacuum is held at steady state during the cooling process and is not relieved until the sheet 16 is sufficiently cooled. The cooling time of the sheet may be monitored by the controller 100, which controls each of the above-described activities. Once the sheet 16 is sufficiently cooled, the vacuum is relieved from the lower half 14 and the upper half 12 withdraws. The frame 17, with excess sheet material, are also withdrawn, thereby leaving the formed sheet 16 accessible for removal from the forming mold 10. This is best shown in Figure 6. A secondary clamping mechanism 110 is used to grasp a perimeter edge of the sheet 16 and carry it through the remaining processes.

[0033] Subsequent to the forming process, the frame and excess material are carried away at step 250 for reprocessing of the excess material and the formed sheet 16 undergoes several finishing processes for producing an end product. These stages preferably include a first quality check, at step 260, primer and coating stages at steps 270, 280, respectively, and a second quality check at step 290. The first and second quality checks 260, 290 are preferably achieved using optical means, such as a camera, for checking the polymeric sheet 16 for any distortion, scratches and/or abrasions. The primer and coating

stages 270, 280 preferably include a wash substep, preferably with water, to remove any dust or other particles from the surfaces of sheet 16 followed by a drying stage and then priming via dip, flow coating or spray process, a primer drying sub-step, a hard coat application by dip, flow coating or spraying process sub-step and a hard coat drying sub-step. It will be appreciated, however, that the hereindescribed finishing processes are merely exemplary in nature and may be substituted for or further include any one of a number of other finishing processes commonly known in the art. Finally, at step 300, the finished sheet 16 is packaged for customer delivery.

[0034] It should be noted that at least the primer and coating stages will be performed under strict temperature humidity and dust controlled conditions to ensure proper flow free coating of sheet 16. The primer coat may be of any suitable material capable of providing a clear distortion free bond with sheet 16 and the top coat. At present, the preferred primer and top coating materials are experimental materials supplied by General Electric Co. applied by a flow coating process that are believed to offer an improved life span of 8-10 years which is significantly longer than currently available materials which may be utilized for this purpose. Preferably the primer and hard coat will be applied to both surfaces of sheet 16.

[0035] Although Figure 8 and the supporting description herein, describe a generally linear processing line for forming polymeric material, it will be appreciated by those skilled in the art that the processing line may vary in layout. For example, it is anticipated that the processing line may be a rotary

line, whereby the processing steps are generally organized as a circle. In this manner, the sheet 16 rotates about the circular layout through each of the processing stages for forming the finished product.

[0036] While it will be apparent that the preferred embodiments of the invention disclosed are well calculated to provide the above-stated advantages, it will be appreciated that the invention is susceptible to modification, variation and change without departing from the proper scope or fair meaning of the subjoined claims.

CLAIMS

What is claimed is:

1. A forming apparatus for forming a sheet of polymeric material, said forming apparatus comprising:

a first mold half having a bottom wall and a first side wall defining a first interior space said first side wall having a first edge;

a second mold half having a top wall and a second side wall defining a second interior space, said second side wall having a second edge, wherein said first and second halves selectively clamp the sheet between said first and second edges for forming the sheet therebetween, whereby the sheet is vacuum drawn into one of said first and second interior spaces;

a cooling mechanism disposed within one of said first and second interior spaces; and

a sensing mechanism attached to one of said first and second halves for sensing a draw depth of the sheet within one of said first and second interior spaces.

2. A forming apparatus for forming a sheet of polymeric material as set forth in claim 1, wherein the sheet includes a peripheral edge and a center portion, whereby said first and second edges selectively support the sheet with said center portion spaced from said first and second mold halves.

3. A forming apparatus for forming a sheet of polymeric material as set forth in claim 1, wherein said first edge is contoured for defining an edge form of the sheet and said second edge is correspondingly contoured for facilitating clamping of the sheet between said first and second halves.

4. A forming apparatus for forming a sheet of polymeric material as set forth in claim 1, wherein said first edge is beveled and said second edge is correspondingly beveled for facilitating clamping of the sheet between said first and second halves.

5. A forming apparatus for forming a sheet of polymeric material as set forth in claim 1, further comprising a trimming mechanism for trimming a perimeter of the sheet to a desired shape.

6. A forming apparatus for forming a sheet of polymeric material as set forth in claim 5, wherein said trimming mechanism comprises a plurality of blades disposed about a perimeter of one of said first and second halves for trimming said perimeter of the sheet upon clamping of the sheet between said first and second halves.

7. A forming apparatus for forming a sheet of polymeric material as set forth in claim 1, wherein said cooling mechanism includes at least one fan.

8. A forming apparatus for forming a sheet of polymeric material as set forth in claim 1, wherein said sensing mechanism comprises a laser fixedly attached to one of said first and second halves for generating a beam of laser light across one of said first and second interior spaces and a sensor for detecting interruption of said beam within one of said first and second interior spaces.

9. A forming apparatus for forming a sheet of polymeric material as set forth in claim 1, further comprising:

a retention mechanism operatively supported by one of said first and second halves for biasing the sheet into contact with one of said first and second edges of the other of said first and second halves.

10. A forming apparatus for forming a sheet of polymeric material as set forth in claim 9, wherein said retention mechanism comprises:

a retention pin slidably disposed within a cavity of one of said first and second halves, and including a pin portion slidable through an opening of one of said first and second edges; and

a spring operatively disposed within said cavity for biasing said retention pin whereby said pin portion extends outward through said opening.

11. A forming apparatus for forming a sheet of polymeric material, said forming apparatus comprising:

a first half defining a first interior cavity and a first peripheral outer edge;

a second half defining a second interior cavity having a second peripheral outer edge;

wherein said first and second halves selectively clamp the sheet therebetween and a vacuum is generated within one of said first and second interior cavities for drawing the sheet therein; and

a cooling mechanism operatively disposed within one of said first and second interior cavities for cooling the sheet from a first temperature upon sufficient drawing of the sheet into one of said first and second interior cavities.

12. A forming apparatus for forming a sheet of polymeric material as set forth in claim 11, wherein the sheet includes a peripheral edge and a center portion, whereby said first and second edges selectively support the sheet with said center portion spaced from said first and second mold halves.

13. A forming apparatus for forming a sheet of polymeric material as set forth in claim 11, wherein said first peripheral outer edge is contoured for defining an edge form of the sheet and said second peripheral outer edge is correspondingly contoured for facilitating clamping of the sheet between said first and second halves.

14. A forming apparatus for forming a sheet of polymeric material as set forth in claim 11, wherein said first peripheral outer edge is beveled and said second peripheral outer edge is correspondingly beveled for facilitating clamping of the sheet between said first and second halves.

15. A forming apparatus for forming a sheet of polymeric material as set forth in claim 11, wherein said cooling mechanism includes at least one fan.

16. A forming apparatus for forming a sheet of polymeric material as set forth in claim 11, further comprising:

a sensing mechanism fixedly attached to one of said first and second halves for sensing a draw depth of the sheet within one of said first and second interior cavities.

17. A forming apparatus for forming a sheet of polymeric material as set forth in claim 16, wherein said sensing mechanism comprises a laser fixedly attached to one of said first and second halves for generating a beam of laser light across one of said first and second cavities and a sensor for detecting interruption of said beam within one of said first and second interior spaces.

18. A forming apparatus for forming a sheet of polymeric material as set forth in claim 17, wherein said sensing mechanism further comprises a reflector for reflecting said beam of laser light within either of said first and second interior spaces.

19. A forming apparatus for forming a sheet of polymeric material as set forth in claim 11, further comprising:

a retention mechanism operatively supported by one of said first and second halves for biasing the sheet into contact with one of said first and second peripheral outer edges of said first and second halves.

20. A forming apparatus for forming a sheet of polymeric material as set forth in claim 19, wherein said retention mechanism comprises:

a retention pin slidably disposed within a cavity of one of said first and second halves, and including a pin portion slidable through an opening of one of said first and second peripheral outer edges; and

a spring operatively disposed within said cavity for biasing said retention pin whereby said pin portion extends outward through said opening.

21. A forming apparatus for forming a sheet of polymeric material as set forth in claim 11, further comprising a trimming mechanism for trimming a perimeter of said sheet to a desired shape.

22. A forming apparatus for forming a sheet of polymeric material as set forth in claim 21, wherein said trimming mechanism comprises a blade disposed about a perimeter of one of said first and second halves for trimming said perimeter of the sheet upon engagement with the other of said first and second halves.

23. A forming apparatus for forming a sheet of polymeric material as set forth in claim 21, wherein said trimming mechanism comprises a series of blades disposed about a perimeter of one of said first and second halves, wherein each of said blades includes an angled cutting edge thereby providing a series of progressive trimming sections along said perimeter.

24. A forming apparatus for forming a sheet of polymeric material as set forth in claim 21, wherein said trimming mechanism comprises a laser trimming apparatus orbital about said perimeter.

25. A forming apparatus for forming a sheet of polymeric material as set forth in claim 21, wherein said trimming mechanism comprises a water-jet trimming apparatus orbital about said perimeter.

26. A method for forming a sheet of polymeric material, comprising the steps of:

heating the sheet to a first temperature;

retaining the sheet between first and second mold halves of a forming mold with the sheet supported along a peripheral edge;

generating a vacuum on one side of the sheet thereby drawing the sheet into an interior space of one of said first and second mold halves while a center portion of the sheet remains supported in space relationship to said first and second mold halves; and

cooling the sheet from said first temperature to a second temperature upon achieving a specified draw depth of the sheet within one of said first and second mold halves.

27. A method for forming a sheet of polymeric material as set forth in claim 26, further comprising the step of detecting a draw depth of the sheet within one of said first and second mold halves for initiating said cooling.

28. A method for forming a sheet of polymeric material as set forth in claim 27, wherein said detecting of said draw depth is achieved using a laser and sensor.

29. A method for forming a sheet of polymeric material as set forth in claim 26, further comprising the step of trimming a perimeter of the sheet to a desired shape.

30. A method for forming a sheet of polymeric material as set forth in claim 29, wherein said trimming of said perimeter is achieved using a blade disposed about a perimeter of one of said first and second mold halves for trimming said perimeter of the sheet upon retention of the sheet between said first and second halves.

31. A forming apparatus for forming a sheet of polymeric material as set forth in claim 29, wherein said trimming of said perimeter is achieved using a series of blades disposed about a perimeter of one of said first and second halves, wherein each of said blades includes an angled cutting edge thereby providing a series of progressive trimming sections along said perimeter.

32. A method for forming a sheet of polymeric material as set forth in claim 26, further comprising the steps of:

relieving said vacuum from said one side of the sheet;

withdrawing one of said first and second mold halves from the other of said first and second mold halves; and

removing said sheet from said forming mold.

33. A method for forming a sheet of polymeric material as set forth in claim 26, wherein said first temperature is greater than or equal to a glass transition temperature of the sheet and less than a melting temperature of the sheet.

34. A method for forming a sheet of polymeric material as set forth in claim 26, wherein said second temperature is less than a glass transition temperature of the sheet.

35. A method for forming a sheet of polymeric material as set forth in claim 26, wherein said heating of the sheet occurs in stages.

36. A forming apparatus for forming a sheet of polymeric material, said forming apparatus comprising:

a first mold half defining a first interior space having a first edge;

a second mold half defining a second interior space having a second edge;

wherein said first and second mold halves come together to selectively clamp the sheet therebetween, whereby the sheet is solely supported by one of the first and second edges throughout a forming process.

37. A forming apparatus for forming a sheet of polymeric material, as set forth in claim 36, further comprising a cooling mechanism disposed within one of said first and second interior spaces.

38. A forming apparatus for forming a sheet of polymeric material, as set forth in claim 36, further comprising a sensing mechanism attached to one of said first and second halves for sensing a draw depth of the sheet during said forming process.

ABSTRACT OF THE DISCLOSURE

A method and apparatus are provided for forming a sheet of polymeric material, such as polycarbonate. A forming mold is provided having halves that engage for forming a heated sheet therebetween. Each of the halves defines an interior cavity having a peripheral edge. The sheet is retained between the peripheral edges of the halves and a vacuum is generated within one of the cavities for drawing the sheet therein, whereby a sensing mechanism detects a draw depth for initiating a cooling mechanism to cool the sheet to a temperature below a glass transition temperature of the material. A series of retention mechanisms are provided about the peripheral edge of one of the halves, for biasing the sheet into engagement with the peripheral edge of the opposing half. A trimming mechanism is further provided for trimming the perimeter of the sheet to a desired form.

Title: Method And Apparatus For Forming High-Impact, Transparent, Distortion-Free Polymeric Materials
Inventors: Edwin J. Oakey et al
Atty. Ref. No.: 1543-000002
Atty: Richard L. Carlson - 248 641-1600

FIG. 1

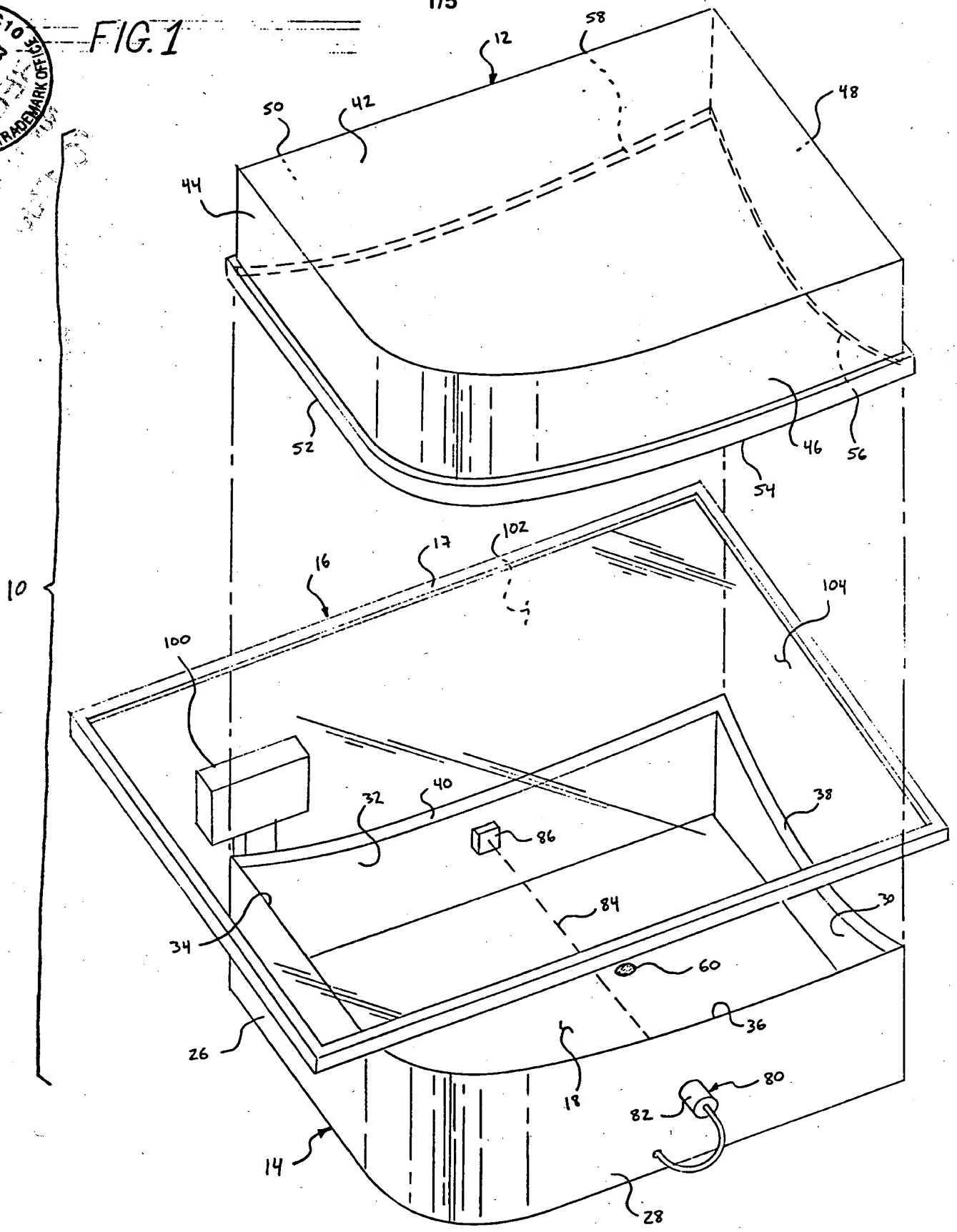
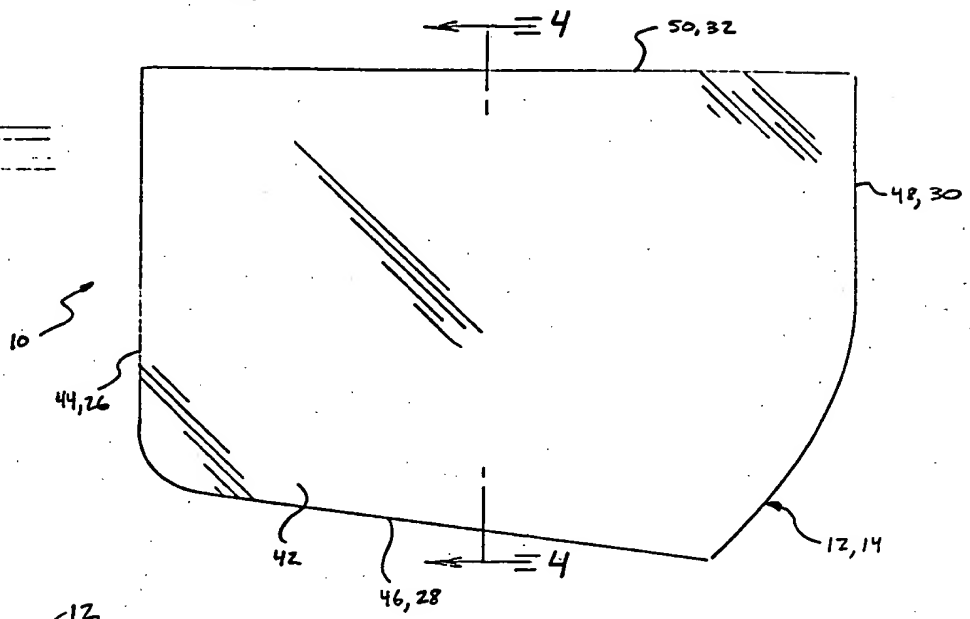


FIG. 2



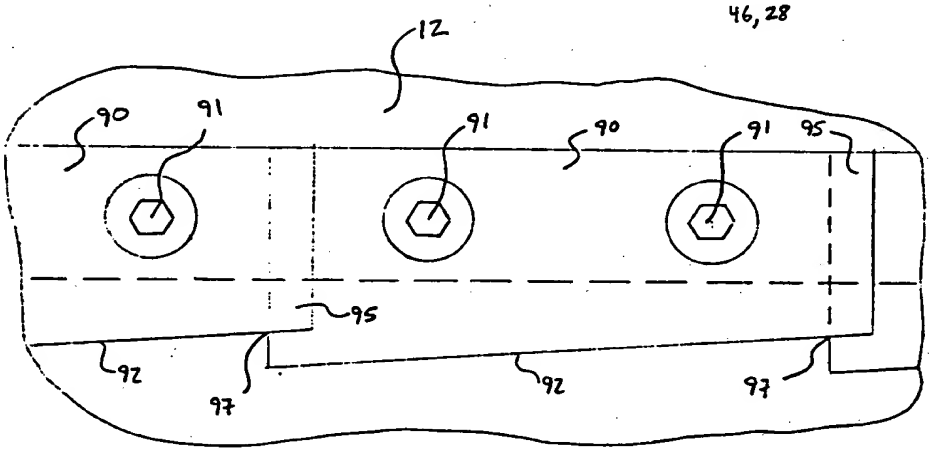


FIG. 5B

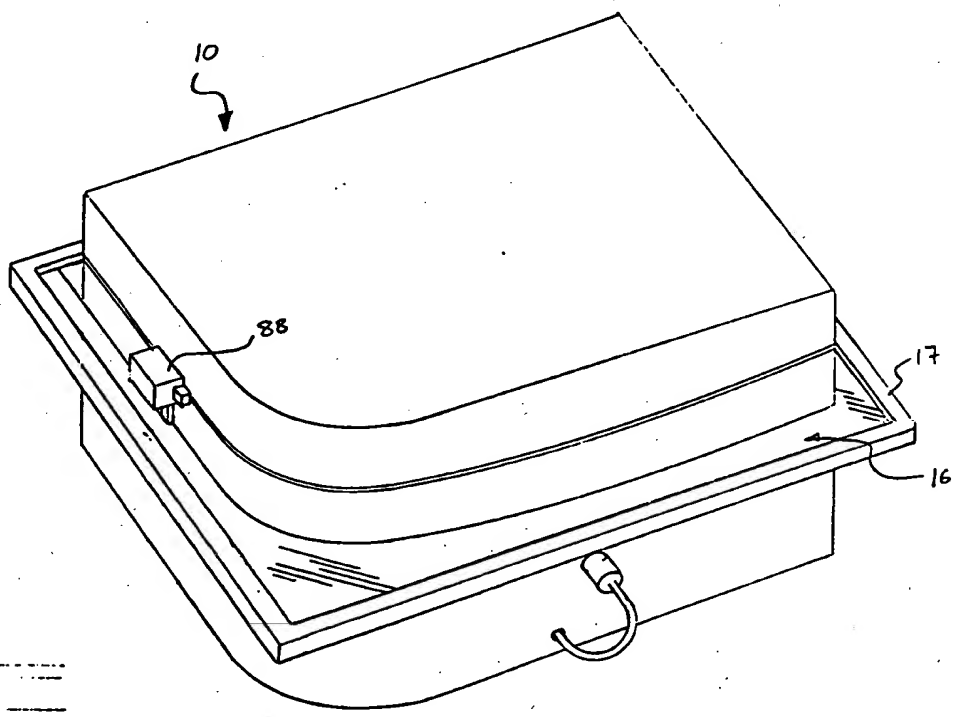


FIG. 7

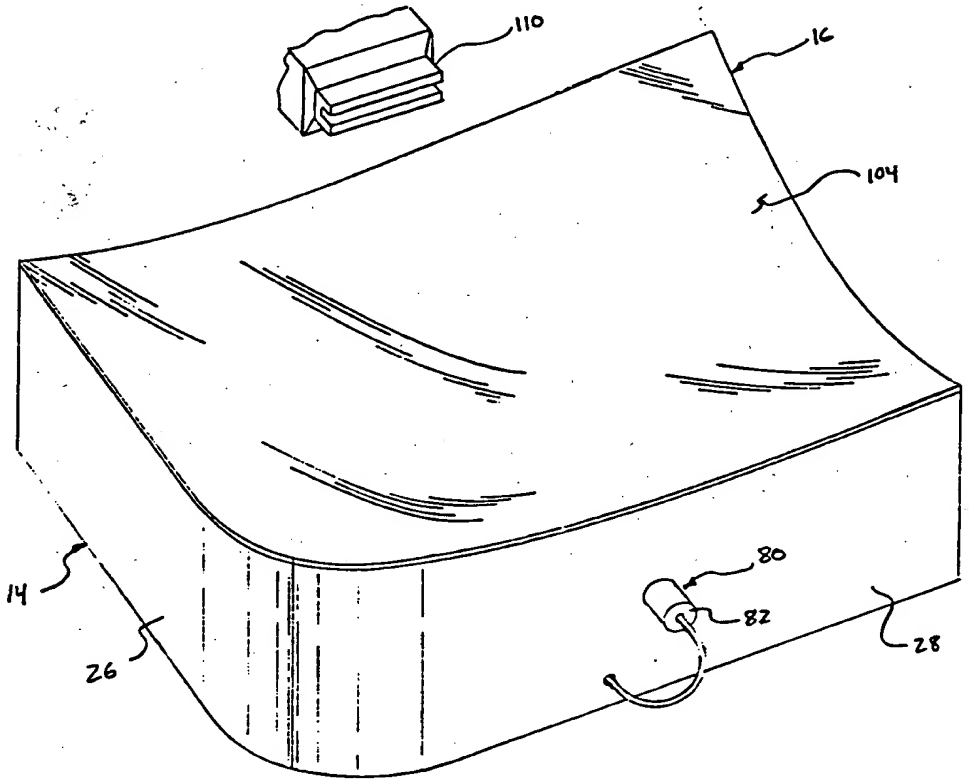


FIG. 6

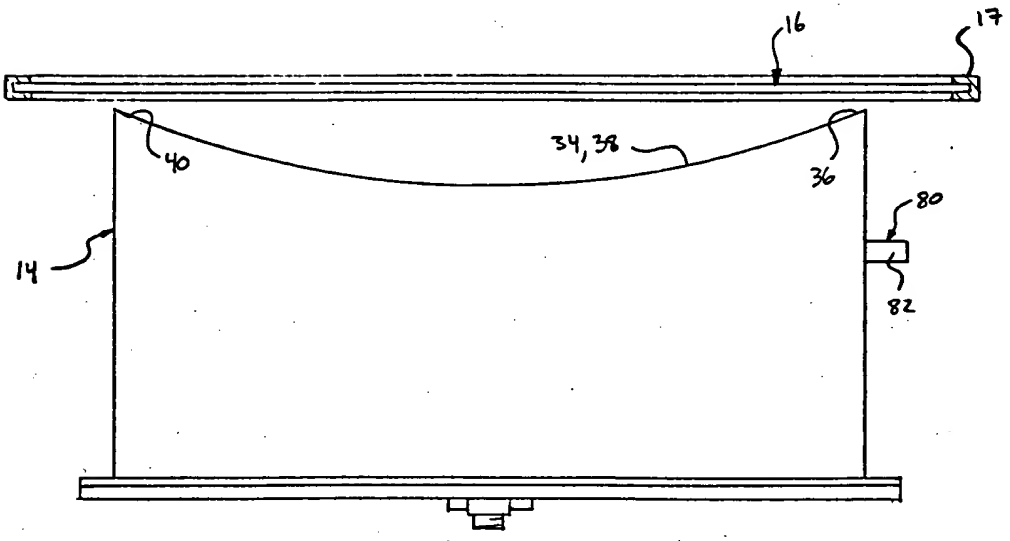


FIG. 3

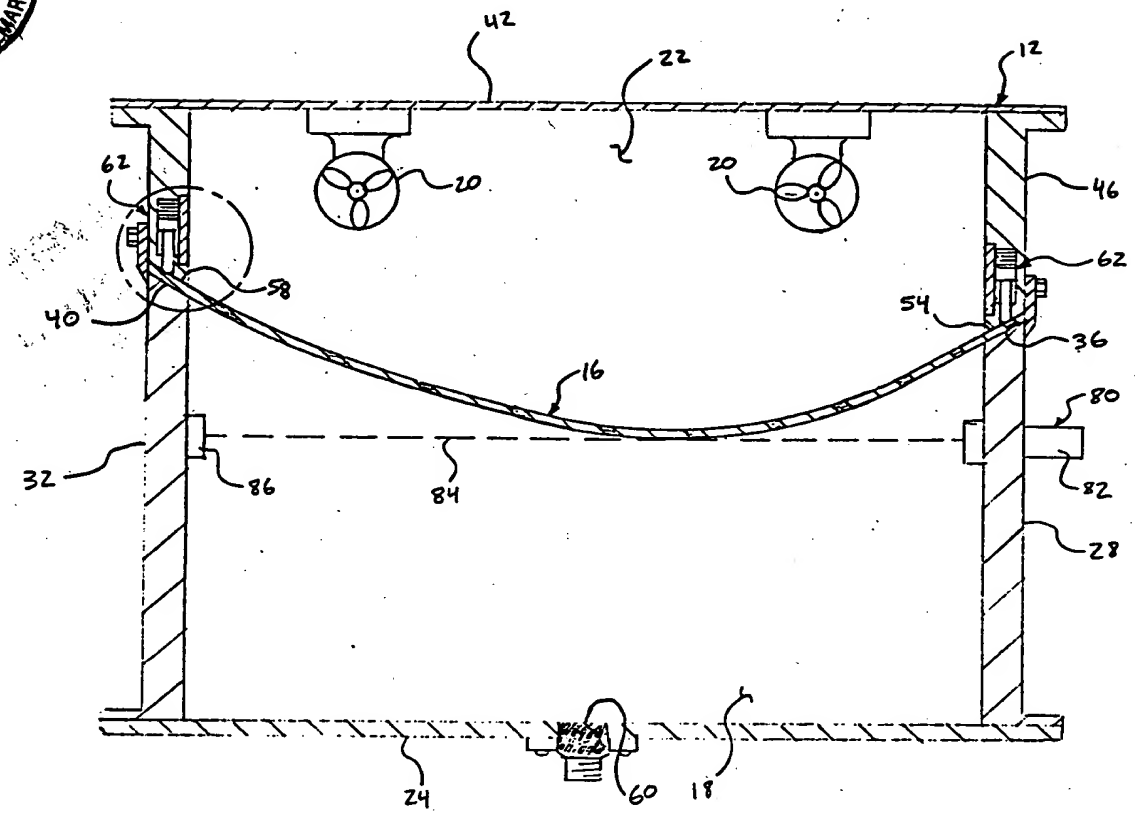


FIG. 4

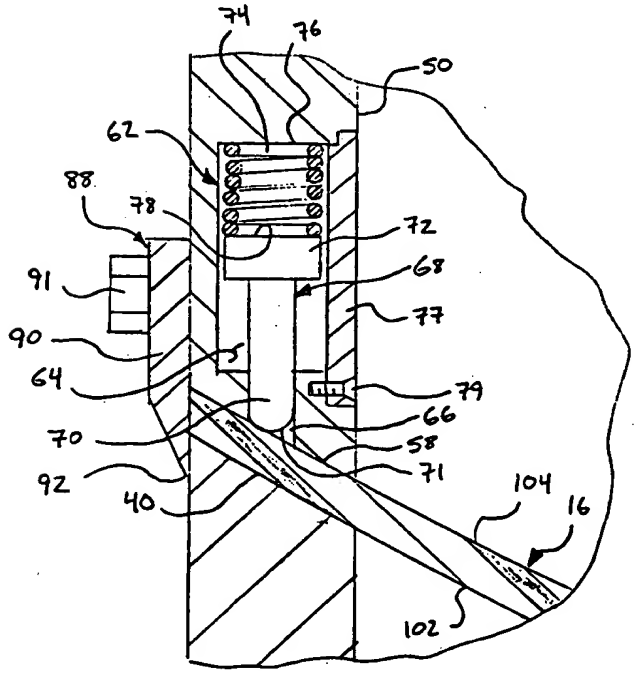


FIG. 5A

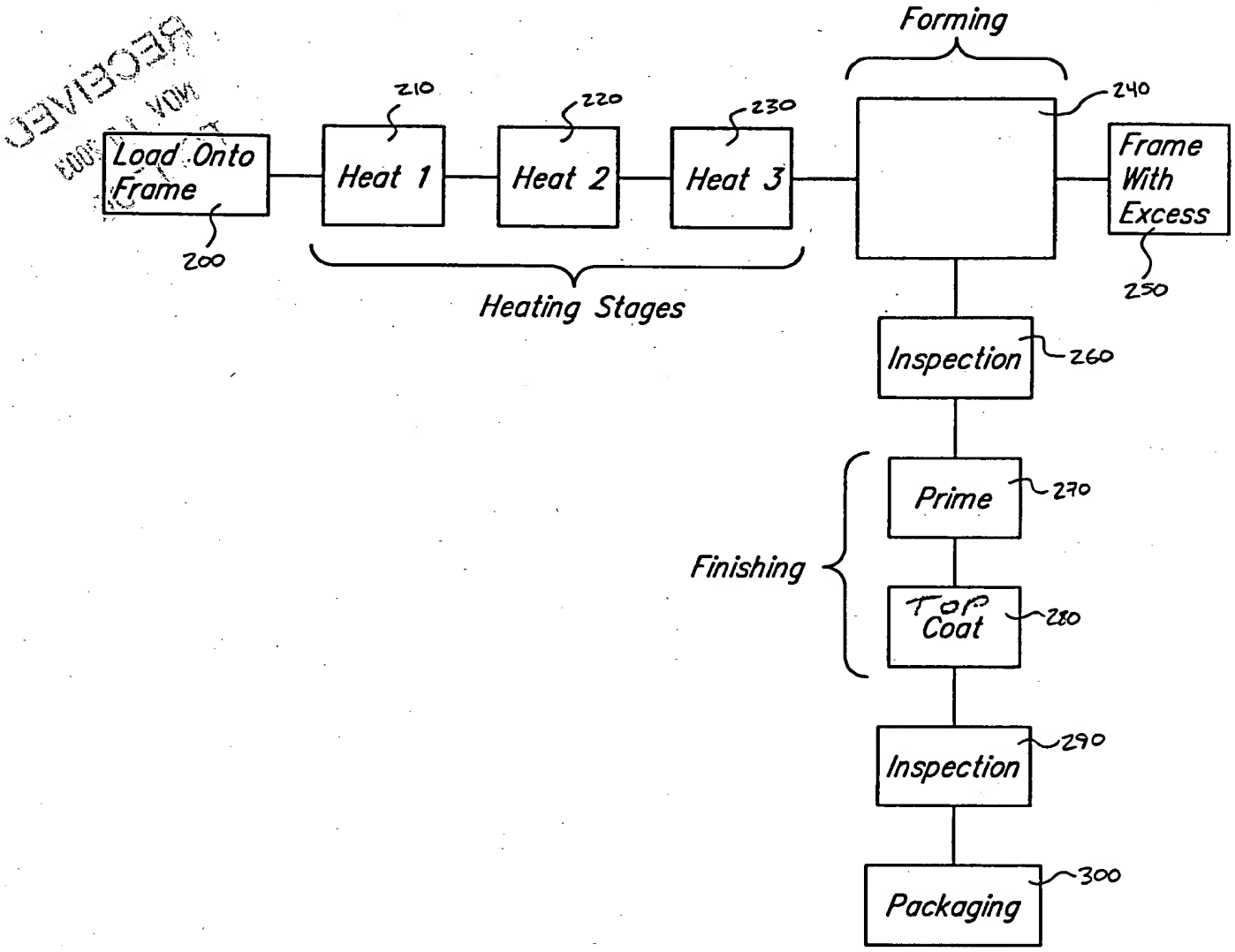


Fig. 8.